Apple II

Five Ways

Five Ways Software

Young's slits

Designer
Melvyn Colley

Programmer
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H·C·E

Heinemann Computers in Education

Starting up

1 Switch on TV monitor(s).
2 Switch on Apple (rear left corner).
3 The disk light should now come on.
4 Insert program disk in the disk drive with light on (see diagram below).
5 Close disk drive door.
6 Wait for a few seconds . . . the program will be entered automatically.

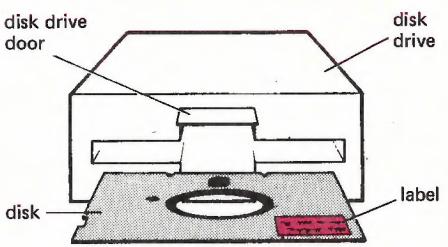
Technical details

Minimum configuration
48K RAM
Autostart ROM
Single disk drive (DOS 3.2 or 3.3)
Applesoft must be in ROM

About the program disk
Disk is single-sided, single density, and copy-protected.
Do not save other programs on this disk, or write-protect it.

How to insert a disk

1 Open the disk drive door.
2 Remove any disk already in the drive.
3 Insert new disk (see diagram).
4 Close disk drive door.



In case you need help

Telephone 021 - 475 1874

Or write to HCE Query Service,
c/o King Edward VI Five Ways School,
Scotland Lane,
Bartley Green,
Birmingham B32 4BT.

For the Apple II

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DEPARTMENT OF APPLIED SCIENCE

Young's Slits

Teaching notes

S.A.C.A.E. — STURT
COMPUTER CENTRE

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The designer would personally like to thank Dr John Tesh for his help in developing this program.

Finally, the team would like to express its gratitude to APPLE UK Ltd for their help and support, without which the production of this software would have been impossible.

Front cover courtesy of Barnaby's Picture Library, London.

1 Introduction

Five Ways Software is a series of resource materials for teaching and learning with the aid of microcomputers. The programs, designed by teachers, and the accompanying teaching notes have been written so that those with little or no knowledge of computers can use the disks with confidence and ease.

There are various ways in which a computer can be used to aid the teaching and learning process. The uses prevalent in schools can conveniently be divided into two main types:

(a) the teacher demonstrates an idea or topic using the computer;
(b) the pupils themselves use the computer.

The equipment requirements for each of these two approaches are rather different, as are the organizational problems involved. A discussion of ways in which the problems may be overcome, even when equipment is limited, may be found in *Computer Software for Schools* (London: Pitman, 1980).

Some teachers will be using computer-aided learning materials for the first time. Section 2.3 (page 6), 'Some suggestions for possible uses', has been included especially for their benefit. The suggestions given are intended to help first-time or inexperienced users increase their appreciation of the versatility of computer-aided learning materials. Once familiarity has been gained, the teacher will doubtless develop his or her own ways of using the materials.

The provision of equipment and the degree of experience in using computer-aided learning materials are only two of the factors that differ from school to school. Class size, range of ability, and teaching methods also vary considerably. As far as possible, these software packs have been designed to take account of these variations and to lend themselves to flexible use. In particular, they can be used to support a variety of teaching styles and may therefore be incorporated into lessons and courses as and when each teacher desires.

Throughout the development of the *Five Ways Software* materials the Project Team has been grateful for the many comments, suggestions, and criticisms that individual teachers have made when viewing early drafts. We hope that this process will continue. To this end, we would value any suggestions for improvements or for other topic areas we might investigate. We can be reached through the

Heinemann Computers in Education Query Service at the address given on the inside front cover of this booklet.

We have enjoyed developing these materials. We hope that you and your pupils will gain enjoyment and benefit from using them.

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2 Notes for teachers

2.1 Program description

Young's experiment demonstrates the constructive and destructive interference produced by two coherent sources of waves. It provides strong evidence for the wave nature of light and therefore occupies an important position in many O and A level courses. The program provides a model of this phenomenon which helps to clarify the pupils' understanding by allowing the investigation of the effect of changing the parameters of the model.

The computer displays two coherent wave trains, each emerging from a slit and converging to a point on a vertical line representing a screen some distance away. The line of direction of propagation of each wave train is also shown. It is possible to erase either the waves or the line of direction of propagation, for greater clarity. The sum of the two waves at their point of convergence is shown on the right of the line representing the screen. To the right of this, it is possible to show a plot of intensity of the sum of waves.

The amplitude of the sum of the waves will vary according to the path difference of the two interfering waves. This path difference depends on the point of convergence of the interfering waves on the screen. Since this point can be moved up and down along the screen, the variation in amplitude can be shown.

2.2 Prerequisites

Pupils should be familiar with concepts of constructive and destructive interference of waves. Although not essential, teachers and pupils may find it advantageous to have used the program *Transverse Waves*, also available in the *Five Ways Software* series (Heinemann Computers in Education, 1982). It is also necessary for the idea of coherent sources to have been introduced.

2.3 Some suggestions for possible uses

Using conventional apparatus, it is extremely difficult to demonstrate how constructive and destructive interference occur along a line due to the interference of two coherent wave trains. It can be explained using a series of diagrams which build up the interference pattern. This program provides a dynamic model in which the point of interference can be varied at will and the effects clearly seen. Nevertheless, it is not intended to replace direct experience of the phenomenon itself. It is suggested that before using this program, the interference pattern is demonstrated by water waves in a ripple tank and by a monochromatic light source incident on a double slit. Details of these experiments are to be found in many textbooks including *Ordinary Level Physics* by A. F. Abbott (London: Heinemann Educational Books, 1977). The computer model could then be used by the teacher as an aid when explaining the theory of the observed wave patterns and to provide resource material for further investigation during class discussion. The program allows the parameters associated with the experiment to be varied and the result observed in a way which is much less difficult than when laboratory apparatus is used.

The following parameters may be varied to investigate their effect on the sum of the waves:

- wavelength of the source,
- separation of the slits,
- amplitude of the interfering waves,
- position of convergence of the interfering waves.

These variations may then be repeated showing the intensity plot. The graph which builds up should be compared to the appearance of the interference fringes produced in the real experiment.

In particular, the effect on the fringe separation of varying the wavelength and slit separation, both independently and together, should be related to the equation

$$\omega = \frac{\lambda D}{s}$$

where ω = fringe separation
λ = wavelength of source
D = distance between slits and the screen on which interference pattern is formed
s = slit separation

It can be demonstrated clearly that the intensity varies continuously along the screen and is not simply a series of sharp maxima and minima. Comparison of the interference pattern with a stationary wave may also be discussed.

Running the program 3

3.1 Changing parameters

Once the title screen has appeared for a few seconds the initial parameter values will be displayed as shown in Fig. 3.1. These values are preset and the program will revert to them each time it is run.

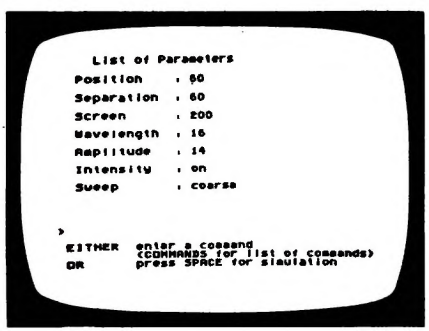

Fig. 3.1

The values may be varied by typing in commands (listed in Section 3.2) in response to the prompt > ■ . In most cases only the first letter of the parameter to be changed is required, since the computer will recognize this and fill out the remaining letters. For example, to alter the wavelength of the source, type W and the computer will instantly convert this to WAVELENGTH (see Fig. 3.2).

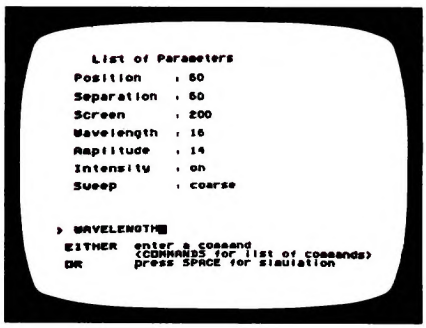

Fig. 3.2

If this is the parameter to be altered, press RETURN to confirm your choice. Otherwise hold down CTRL and press X. This will remove WAVELENGTH from the screen and allow you to select a different parameter. After confirming your choice the required value for the parameter may be entered.

Note For the commands SWEEP, SCREEN, and SEPARATION a second letter is required to identify the command uniquely.

The intensity plot is initially 'on'. To change this, type I (which the computer will fill out to INTENSITY) followed by RETURN. The intensity plot will then be switched off and will not appear. Similarly, sweep can be set to 'coarse' or 'fine'. The point at which interference takes place may be moved vertically while the wave system is displayed. If sweep is set to 'fine' this movement will be in small steps; if it is set to 'coarse' the steps will be larger.

When all the required parameters have been changed,

- press the space bar to display the wave system (shown in Fig. 3.3).

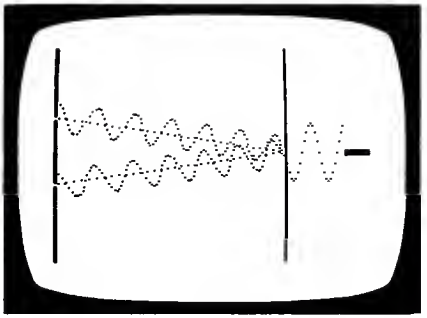

Fig. 3.3

3.2 List of commands

The commands are grouped under four headings:

(a) Parameter selection
(b) Display selection
(c) Commands during animation
(d) Other commands

A full list of commands is shown below.

Parameter selection[1]	
AMPLITUDE	Changes amplitude of source wave
POSITION	Changes distance between upper slit and top of display
SCREEN	Changes distance between position at which waves combine (the 'screen') and the slits
SEPARATION	Changes distance between slits
WAVELENGTH	Changes wavelength of source wave

Display selection	
INTENSITY	Sets intensity plot to on/off
SWEEP	Sets sweep step to coarse/fine

[1] Units of amplitude, velocity, and wavelength are arbitrary.

Commands during animation
(These keys are used whilst actually viewing the wave display and are fully explained in Section 3.3.)

W	Sets wave display to on/off
S	Sets sum of waves display to on/off
A	Sets axes display to on/off
U	Moves **up** the position at which the waves combine
D	Moves **down** the position at which the waves combine

Other commands

COMMANDS	Lists valid commands
RESET	Resets the initial parameter values

3.3 The wave display

Two of the three screens (parameter selection screen and commands screen) have already been described. The third screen shows the wave diagram. The wave display (Fig. 3.3) may be reached from the parameter selection screen by pressing the space bar

When the wave display is on view, you can press

W	to remove/add the two coherent waves;
S	to remove/add the sum of the waves;
A	to remove/add the axes of the waves;
U	to move **up** the position at which the waves combine;
D	to move **down** the position at which the waves combine.

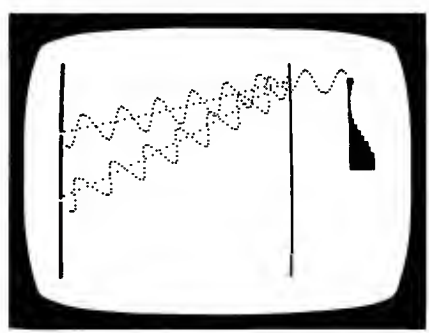

Fig. 3.4

If sweep is set to 'fine', the summing position will move in small steps when U or D is pressed; if it is set to 'coarse' this movement will be in larger steps. If the intensity plot is switched on, the intensity of the summed wave at each vertical position will appear to the right of the wave display as shown in Fig. 3.4.

To move the point at which the waves combine continuously up (or down):

- press and hold down U (or D) while you
- press and hold down REPT

The movement will continue until the keys are released.

It is possible to return to the parameter selection screen from either the wave display screen or the list of commands by pressing ESC The list of commands has two pages. You can change the page displayed by pressing C. The procedure for moving between the screens is summarized in Fig. 3.5.

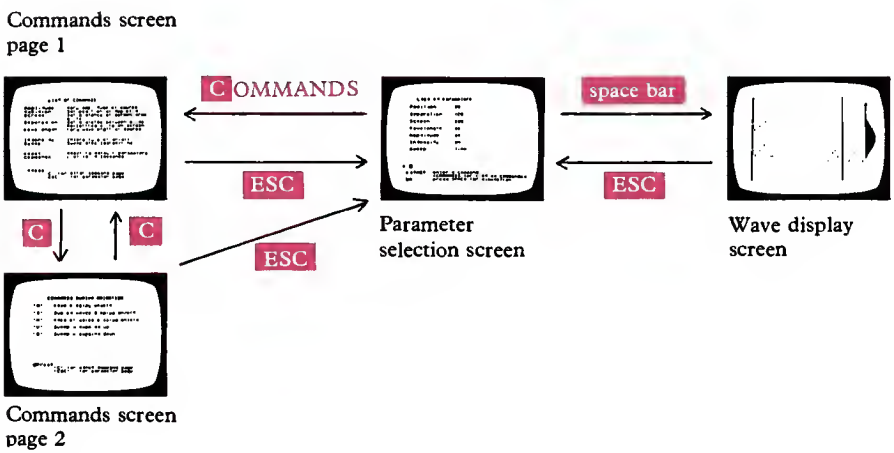

Fig. 3.5

3.4 Special keys

Most of the keys that perform special tasks have been introduced already. There are two others:

←

Typing errors can occur when you enter parameter values. The last character you typed can be cancelled by pressing ←. Each time this key is pressed another character is erased.

space bar

This key has an additional function when viewing the wave display screen. Each time it is pressed the wave display stops or restarts. The display can thus be frozen (or unfrozen) at will.

The functions of all the special keys are summarized inside the back cover.

3.5 Leaving the program

The program is terminated as follows:

From the wave display screen

- press ESC for the parameter selection screen;

From the parameter selection screen

- press ESC to finish.

Instructions will appear which tell you when to remove the disk and switch off the computer.

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Summary of special keys

space bar — has two functions:
(a) it changes the parameter selection screen to the wave display screen;
(b) it stops or restarts wave movement on the wave display screen.

ESC — displays the parameter selection screen.

W — sets the **wave display** on/off.

S — sets the **sum of waves** display on/off.

A — sets the **axes** display on/off.

U or D — moves the position at which the waves combine **up** or **down**.

RETURN — confirms commands or values that have been entered from the keyboard.

CTRL X — cancels any entered command or value if pressed before RETURN has been pressed.

← — cancels the last character entered if pressed before RETURN has been pressed (this applies only to values, not to commands).

Apple II

Young's experiment provides strong evidence for the wave nature of light and therefore forms an important part of many physics courses leading to public examinations. However, the phenomena are extremely difficult to demonstrate using conventional apparatus. This program provides a dynamic model of the experiment.

The amplitude and wavelength of the source waves, separation of the slits, and position of convergence can be varied and the results discussed. The source waves, resultant wave, and their axes may all be switched on and off while the simulation is displayed and, in addition, an intensity plot may be displayed and its implications considered.

This model may be used for both classroom demonstration and individual learning. It allows a step-by-step investigation of all the important theoretical concepts associated with the experiment.

Five Ways Software is a series of resource materials for teaching and learning with the aid of microcomputers. The programs have been designed by teachers and written so that those with little or no knowledge of computers can use the disks with confidence and ease.

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